l', the self-induction of same;

r, the resistance of same;

p, the pulsation of the fundamental wave of tension and current.

We can use a fictive circuit (fig. 1) instead of the actual circuit, and assume: 1st: the capacity of the receiving circuit is divided in two capacities c' and c'', one of which, c'' gives the resonance with the self-induction l of the alternator, while the other, $c^1$ gives that of the self-induction S of the receiving circuit and of the lines.

2nd: the self-induction and ohmic resistance of the receiving circuit and of the lines, are separated in two circuits, R and S, one having the ohmic resistance R, the other the self-induction S. Then, if the resonance is reached between 1—2 and 3—4 the current $I_1$ supplied by the alternator A will be the resultant of the currents $I_2$ and $I_5$, making an angle of 90 degrees. The tension V at the terminals, of the alternator, will be in phase with $I_5$.

Fig. 2 shows the vector diagram of the currents and the tensions; O $E_0$ is the elm. force at no load; O e'' the the elm. force produced at the resonance load in the armature by the flux resulting from the normal excitation and the armature current; oi and oi' are the two components of the current $I_1$, one of which is in phase, the other in lag of 90 degrees with the elm. force at no load. These compon-

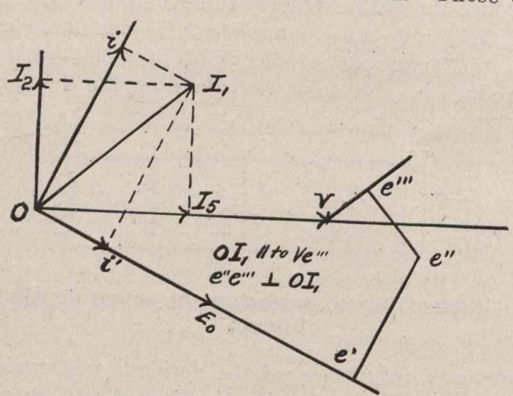


**Fig. 2.—Vector Diagram.**

ents produce in the armature the opposite and cross reaction. We can see that V is much greater than $E_0$. The resonance phenomena take place in the circuit 3 — 4 when

$$p\,l' = \frac{1}{p\,c'}$$

and likewise in circuit 1 — 2, when

$$p\,l = \frac{1}{p\,c''}$$

and since from $c' + c'' = c$, we obtain

$$p^2 c = \frac{l + l'}{l\,l'}$$

If we substitute $\frac{l\,l'}{l + l'} = L$ the condition of the resonance will be then:—

$$p^2 c\,l = 1$$

As we said above, the dangerous effects of resonance are not to be feared for normal frequency, that is for the fundamental wave, but the higher harmonics may produce this resonance with harmful result.

In a circuit supplied with alternating current at 60 cycles, the frequency of the 5th harmonic is 5 x 6. 28 x 60 = 1885 and in this case in order that the 5th harmonic give the resonance, we must have

$$c\,l = .28210^6.$$

From $L = \frac{l\,l^1}{l + l^1}$ we can see that the influence on L of an increase of the alternator's self-induction is not very great, but it might be sufficient to eliminate the currents of higher frequency. The advantage of using compound alternators is also shown by fig. 1; the component of the current in lag of 90 degrees with $E_0$ is ahead of the no-load elm. force. The result is that it has a magnetizing effect on the armature circuits. If the armature reactions were compensated as happens in the compound generators, there need be no fear of the magnetizing effect of the armature current. On the other hand, it has been often shown that the construction of compound alternators with a higher self-induction and armature reaction would be more economical than that of the machines built at the present time for a low tension drop.*

It is difficult to see where improvements with regard to reducing the size and cost of alternator for a given output can be made, for although many attempts have been made to get a satisfactory compounding device, none of these have been very successful up to the present time. One of the reasons is that most of these devices have been fitted to the exciter with the result that to the field excitation lagged behind the change of load. It is therefore probable that compounding devices which are not directly applied to the alternator will never be entirely successful.

The higher harmonics of the tension may produce the breaking of cable insulation, and its effects are the more to be feared because the resonance of these harmonies, that is to say, the increase of its amplitude, is not generally shown at the voltmeters and other apparatus.

The engineers at the power-house could, therefore, not be warned of this increase of the tension, except by the breaking of the cable insulation in the circuit.

The importance of these facts is easy to see, especially if we consider that the resonance of the lower harmonics depends on the values of the self-induction and capacity of the circuits, increasing with the development of lines and underground cables.

From this point of view, the test of cables at a higher tension than the distributing tension is not sufficient, because a dielectrikum does not resist so well at high frequency as at low frequency.

Accidents of resonance may be avoided by the use of high self-induction alternators giving a sine curve elm. force. However, the use of such alternators may not be sufficient, because in many cases the generators are not connected directly with the distributing lines. The transformers placed in the circuits to increase or reduce the tension at the generating or receiving end, can, as shown long ago by Rowland, alter the wave by the variation of the permeability with the induction. The dangers of resonance may still continue, but we may add, that the low induction generally admitted by the transformer cores will not cause any great change in the wave of the elm. force.

To avoid accidents through resonance in underground circuits, it becomes necessary to take the tension curves at the power station with an oscillograph. In this way it may be easily ascertained whether the harmonics are present or if their amplitudes do not reach an excessive value.

It may, however, also be necessary to take tension scillograms of the motors supplied by the circuits because the resonance of their own harmonics may be produced by the self-induction and capacity of a local circuit in which currents of high intensity would be produced.

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*On this question we could mention an interesting work of McFarlane and Barge, recently published in the "Electrician" (11 and 18, of December, 1908.)

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The statement was made in Wall street recently that Harriman pacific roads have now under construction 2,000 miles of extensions, with expenditures approximating $100,-000,000.

According to the latest statistics the total peat-bogs of Sweden would be capable of producing 10,000 millions of tons of air-dried peat, suitable for fuel. This quantity, as compared with the present import of coal, would be sufficient for a period of 1,500 years. More exact examinations of the geological character of the peat-bogs will soon be started by the Swedish Geological Society.